NORTHSTAR-AT-TAHOE RESORT LOOKOUT MOUNTAIN TEST PLOTS REPORT

May 2008

INTRODUCTION

This report describes monitoring data and results from the Northstar-at-Tahoe Resort tests plots (Northstar test plots) and a native reference plot. The Northstar-at-Tahoe Resort is located in Placer County, California, just off Highway 267 in between Truckee and King's Beach (Figure 1). The plots are on Lookout Mountain, at the bottom of the Martis ski run (Figure 2). The Northstar test plots were built in 2003 and monitored in 2004-2007. A total of 24 treated plots and three control plots were installed at the Northstar test plot area.

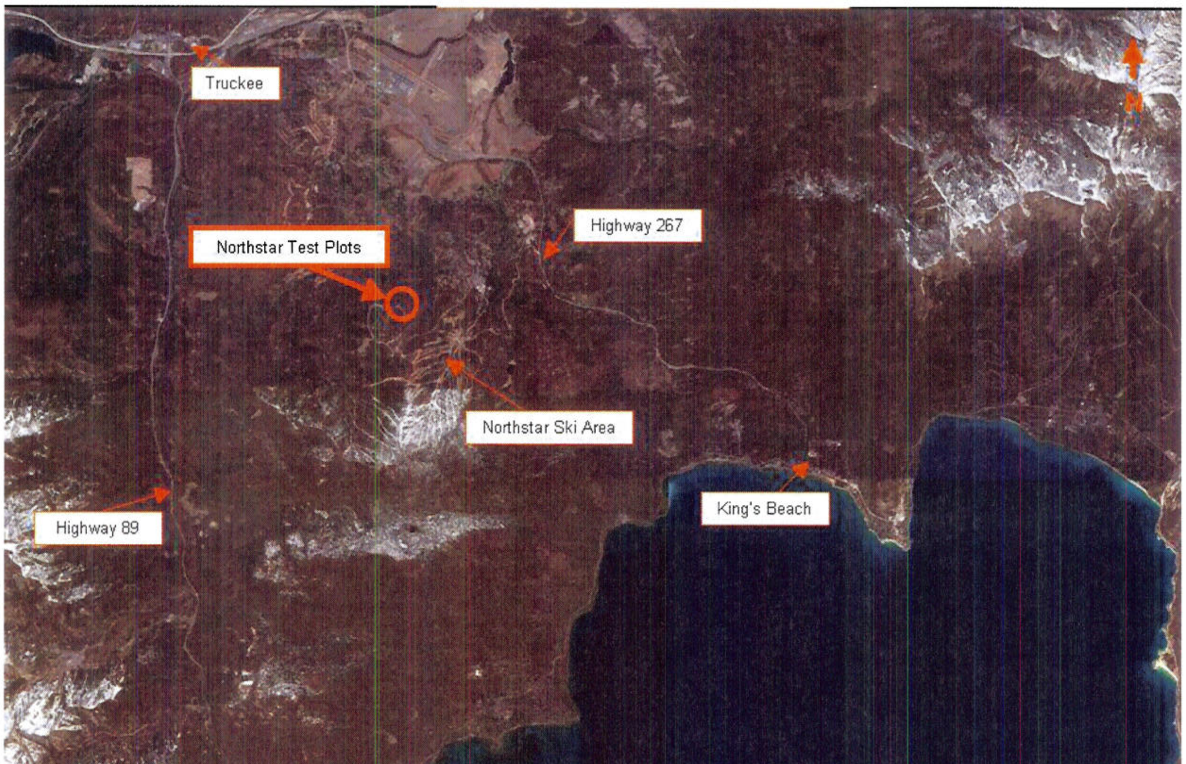

Figure 1. Satellite map of Northstar location. Northstar is located just northeast of Lake Tahoe.

A native reference area was set up just to the west of the test plots (Figure 2). Previously, this area was treated by rough grading and the removal of tree stumps and rocks. Prior erosion control treatments were not applied to the area, but intermediate wheatgrass and orchard grass, both used in nearby re-vegetation projects, were present at the site. The test plot soils, which are derived from volcanic parent material, are similar to many soils in the area, including roadside cut slopes. Therefore, the monitoring results from this project will have applications for land managers throughout the Lake Tahoe Basin region.

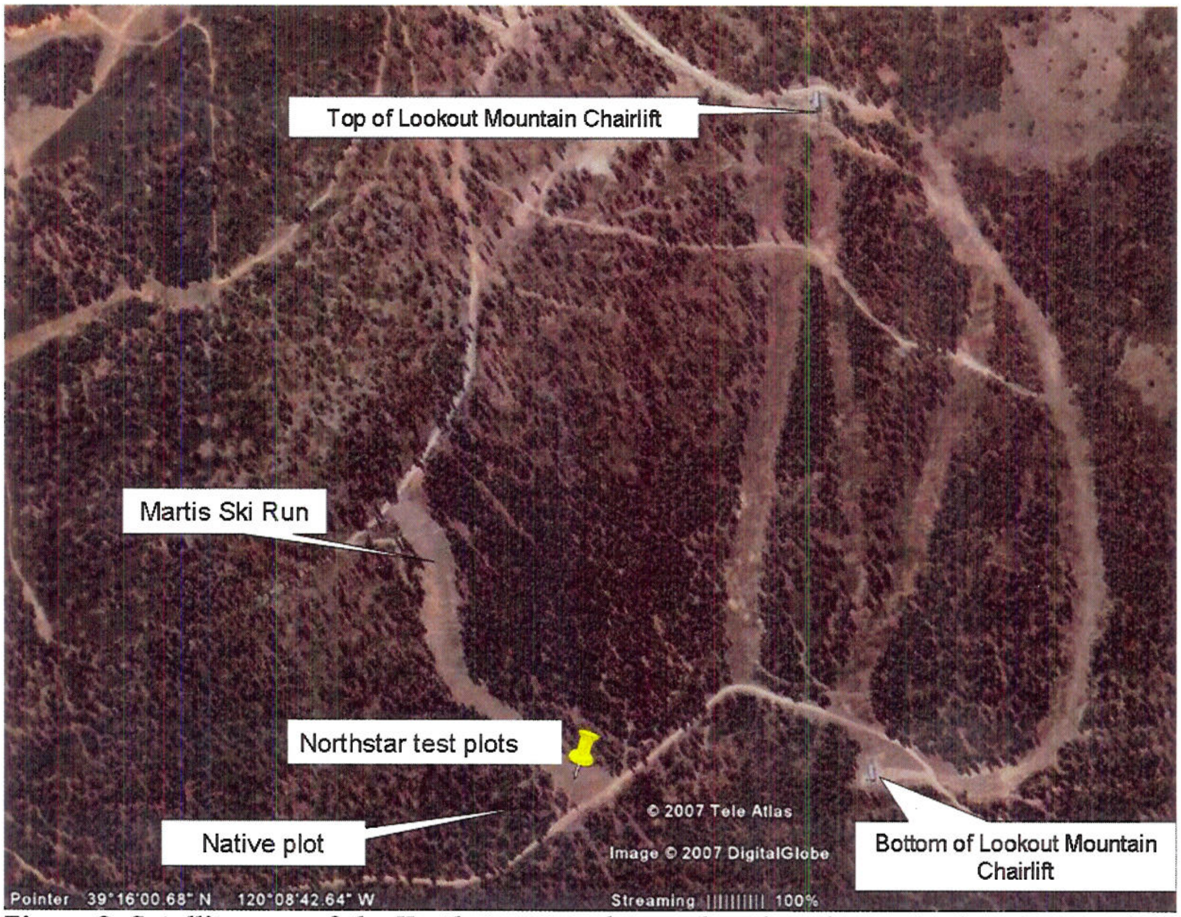

Figure 2. Satellite map of the Northstar test plots and native plot on Lookout Mountain's Martis ski run.

PURPOSE

These test plots were installed to create long term soil research plots on soil derived from volcanic parent material. The findings from this research can be applied to Caltrans roadside restoration in the Lake Tahoe area. The specific objectives were to investigate the effects of eight treatment types on soil density, soil nutrient status and infiltration. The treatment variables were: tilling versus no tilling, Biosol fertilizer rate, and amendment type (compost versus coarse overs). All treatment areas received a native grass seed mix (Table 2). Initially, these plots were created for soil research; therefore, plant cover was estimated ocularly in 2006. However, after observing differences in plant cover and species composition by treatment in 2006, cover point monitoring was used in 2007 to obtain a statistically defensible measure of plant cover by species. The cover point method aided in further investigating the trends observed in 2006.

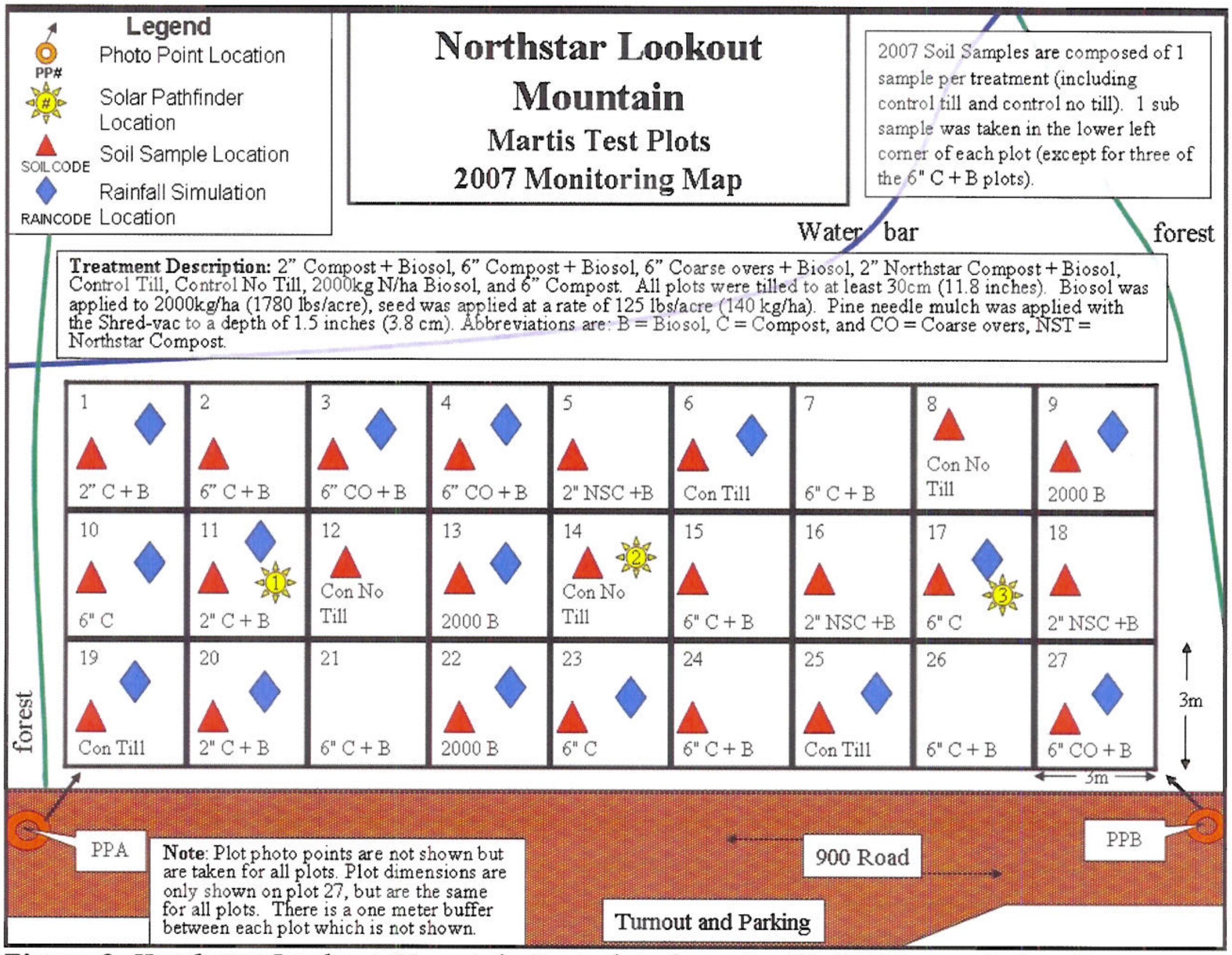

Figure 3. Northstar Lookout Mountain test plots layout with 2007 sample locations marked.

SITE DESCRIPTION

The test plots are located at the bottom of Martis ski run on a northwest facing slope with an angle of approximately 30 degrees. Soils in and surrounding the test area are derived from volcanic parent material. Local native vegetation consists of a mixed conifer forest with Jeffrey pine (Pinus jeffreyi) as the dominant overstory species and white fir (Abies concolor) as co-dominant. The understory is composed of the native shrubs chinquapin (Chrysolepis chrysophylla), huckleberry oak (Quercus vaccinifolia), Squaw carpet (Ceanothus prostratus), snowbrush ceanothus (Ceanothus velutinus) and green leaf manzanita (Arctostaphylos patula). There are few forbs or grasses in the forest understory. On the open slopes, native and non-native herbaceous species are common. The site elevation is 6,721 feet (2,049 m) above mean sea level (AMSL). The soils in the test plot area are of volcanic origin and have on average of 50 percent coarse material (greater than ½ inch, or 1.75 centimeters diameter). Soil particle analysis, conducted in 2007, classified the soil as a sandy loam or a sandy clay loam with between 60 and 65% sand, 18% silt, and between 15 and 21% clay-sized particles. Prior to the 2003 test plot treatment, the area was mostly vegetated with wheatgrass (Agropyron sp.) and orchard grass (Dactylis glomerata), both non-native perennial species often used in re-vegetation projects (Figure 4). Rills and sheet erosion were visible at the site before test plots installation.

METHODS & MATERIALS

Treatment Overview

Twenty-seven 10 foot by 10 foot (3 m x 3 m) plots with a 3.3 foot (1 m) buffer on all sides were placed in a grid nine plots wide by three plots long. Twenty-one of the plots received "full treatment", meaning that amendments were tilled in, and fertilizer, seed, and mulch were applied (Table 1). There were two different types of control plots: control till and control no till. The control till plots did not receive amendments, were tilled, and mulched. The control no till plots were not tilled and did not receive amendments, but were mulched. There were three replicates of each control treatment, for a total of 6 control plots. Treatments were randomly located within the treatment area (Table 1 and Figure 3.).

Table 1. Treatment Types

Plot numbers	Treatment
9,13, 22	2,000 kg/ha Biosol
1, 11, 20	2" compost and Biosol
5, 16, 18	2" Northstar-at-Tahoe compost (NSC)
3, 4, 27	6" Coarse overs plus Biosol
10, 17, 23	6" compost
2, 7, 15, 21, 24, 26	6" compost and Biosol
6, 19, 25	Control – till
8, 12, 14	Control – no till

Test Plot Treatments

First, amendments were spread over the test plots. Three different materials applied at two different rates were used on this project. The Full Circle Integrated Tahoe Blend 75%, obtained from Full Circle Compost (Minden, NV) contains 75% humus fines of 3/8 inch (0.95 cm) or smaller and 25% coarse overs. This was applied at two different rates. A composted woodchip material, hereafter referred to as coarse overs, was applied at one rate. A locally produced Northstar-at-Tahoe compost (NSC) was also applied at one rate. These amendments were applied to each plot using a Gradall reach forklift equipped with a loading bucket prior to tilling the soil.

Full Circle compost was applied at two depths: 2 inches, at a nitrogen equivalent of approximately 2,000 lbs nitrogen/acre (2,241 kg/ha) and 6 inches, at a nitrogen equivalent of approximately 6,000 lbs/acre (6,725 kg/ha). Six inches of coarse overs were applied at a nitrogen equivalent of approximately 3,500 lbs/acre (4,000 kg/ha). Local Northstar-at-Tahoe compost (NSC) was applied to a depth of 2 inches at a nitrogen equivalent of approximately 2,600 lbs/acre (2,900 kg N/ha).

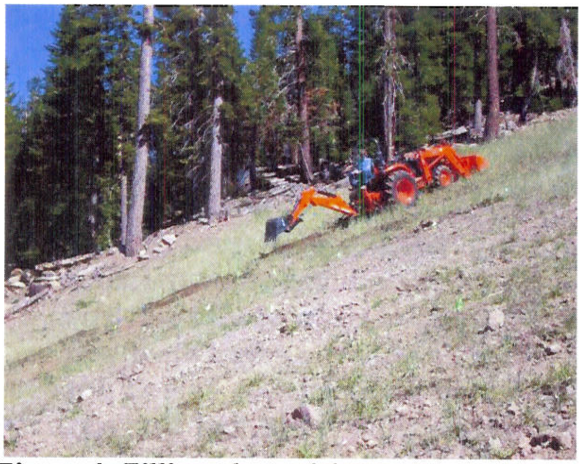

Figure 4. Tilling plots with a Woods backhoe on a Kubota tractor.

Figure 5. Close up of tilling with the Kubota.

After the amendments were applied, the plots were tilled to a depth of at least 12 inches (30 cm). Tilling of the soil was completed with a Woods backhoe attached to a Kubota 3830 tractor (Figure 4 and Figure 5). Each plot was tilled with the tractor positioned on the uphill side of the plot and the backhoe was used to break up the soil to a minimum of 12 inches (30 cm). Due to logistical problems and the steepness of the slope, plots 1, 2, and 11 were tilled with a Gradall 43 foot (13 m) reach forklift.

Biosol organic fertilizer, which has a 6-1-3 nitrogen-phosphorous-potassium ratio, was applied on specific plots at a nitrogen equivalent rate (N) of 107 lbs N/acre (120 kg N/ha), or a bulk rate of 1780 lbs Biosol/acre (2,000 kg/ha). The Biosol was applied by hand after each plot was tilled. The Biosol was then raked into the soil surface to a depth of 1 inch (2.5 cm). The plots were then seeded with grass seed (Table 2). The grass seed was applied at an equivalent pure live seed (PLS) rate of 125 lbs/acre (140 kg/ha). The seed was lightly raked into the soil surface after application to ensure adequate contact with the soil.

Table 2. Seed mix species composition.

Species	% mix	Portion Viable	Pure Live Seed (PLS)
Mountain brome	29.01	0.87	25.2
Squirreltail	26.56	0.95	25.2
Blue wildrye	24.58	0.77	18.9
Western needlegrass	12.62	0.75	9.5
Total	92.77*		78.9
* The remainder was inert material.			

Approximately 40 square yards (30.5 m^3) of pine needles were used to mulch all test plots to a depth of approximately 1.5 inches (3.8 cm). After the pine needle mulch was applied, a paddle agitator-equipped hydroseeder was then used to apply tackifier to the entire treatment area. The tank was filled with water and one 50 lb (23 kg) bag of tackifier, which included ½ a bale of wood fiber mulch. Two even applications were sprayed on the entire test plot area.

Figure 6. Northstar test plots, pre-treatment. Rills are visible between the grass stands.

Figure 7. Northstar plots post treatment, 2004.

Figure 8. Northstar test plots, post-treatment, 2007, after three growing seasons.

Monitoring

In 2006, penetrometer and soil moisture sampling were performed at each numbered test plot as well as at the native area, in a random pattern. Soil samples were also collected at select plots. Rainfall simulation was performed on five of the eight test types in 2006, as well as at the native reference area. In 2007, full suite monitoring (penetrometer, soil moisture, cover, shear strength, and soil samples) was conducted for each test plot treatment type, with three replications for each type. Rainfall monitoring was conducted for six of the nine treatment types. The native reference plot was not monitored in 2007 since it is unlikely that there would be large differences between the 2007 and 2006 sampling data.

Cover

The affect of treatment type on plant cover was not specified as a research question before in depth sampling was performed in 2006. Therefore, until 2007, the more precise and statistically valid cover point method of assessing plant cover was not conducted at this site. Instead, ground cover by mulch and foliar cover by plants were ocularly estimated at each plot in 2006. Ocular estimates of cover are subjective and vary by examiner. The ocular cover estimates can not be compared with cover point values, but can be used to detect general differences among plots and treatments.

In 2007, cover was measured using the cover point method along randomly located transects.[1] The cover pointer consists of a metal rod with a laser pointer mounted 3.3 feet (1 m) high. After the rod was leveled in all directions, the button on the laser pointer was depressed and two cover measurements were recorded (Figure 9 and Figure 10):

1) the first hit cover, which represents the first object intercepted starting from a height of 3.3 feet (1 m) above the ground and
2) the ground cover hit.

The first hit cover measures the foliar cover by plants (leaves and stems). It does not measure the part of the plant actually rooted in the ground. The ground cover hit measures whatever is lying on the ground or rooted in the ground (i.e litter/mulch, bare ground, basal (or rooted) plant cover, rock and woody debris). Total ground cover represents any cover other than bare ground.

Plant cover both on the ground and foliar were recorded by species and then organized into cover groups based on four categories: lifeform (herbaceous/woody), perennial/annual, native/alien (2007 only), and seeded/volunteer (2007 only). Perennial herbaceous species includes seeded grasses, native grasses and forbs and any non-native perennial species. Some of the perennial grasses are commercial wheatgrass cultivars (Agropyron sp.) commonly used by ski resorts. Though many of these species are native to the western United States they do not occur naturally in the local ecosystem. Annual herbaceous species included native annuals such as willow herb (Gayophytum sp.) and introduced species such as goosefoot (Chenopodium album). Fewer non-native species were present at this site than a typical road cut, mostly because it is isolation from such seed sources. Woody species are any tree and shrub species of interest, whether native or introduced. Each species was then classified based on whether it was native to the Tahoe area, and whether it was seeded during treatment. Data is also presented on the amount of cover by species. Species of interest are species that were seeded and problem species, such as invasive annuals. An ocular estimate of cover at

---

[1] Hogan, Michael. Luther Pass Monitoring Report: Plant and Soil Cover Monitoring for Evaluating Sediment Source Control Success in the Lake Tahoe Basin. 2003. South Lake Tahoe, CA, Lahontan Regional Water Quality Control Board.

each plot was also recorded in 2006 and 2007 and includes many species not picked up in the cover point sampling (Appendix A).

Figure 9. Cover pointer in use along transects.

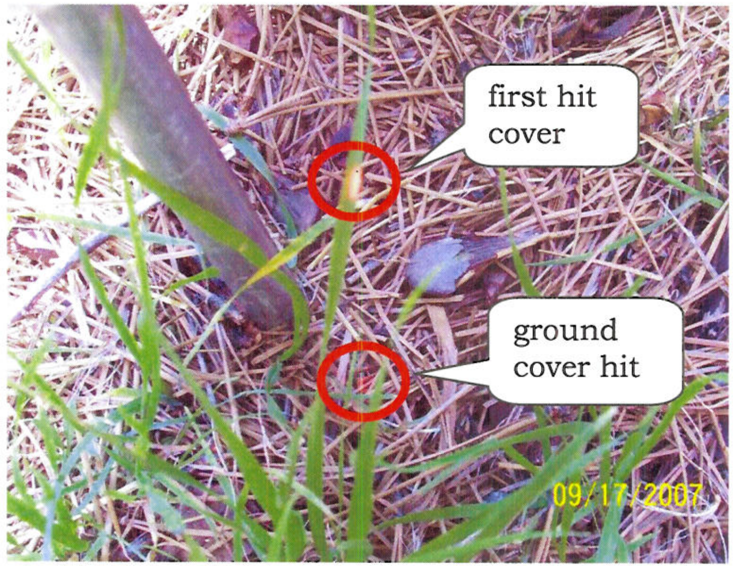

Figure 10. Cover pointer rod with first hit and ground cover hits by the laser pointer. The laser pointer hits are circled in red. The first cover hit is a native grass and the ground cover hit is pine needle mulch.

Soil and Site Physical Conditions

Penetrometer

A cone penetrometer was used to measure soil compaction. The cone penetrometer with a ½ inch diameter tip was pushed straight down into the soil until a maximum pressure of 350 pounds per square inch (psi) (2411 kPa), was reached (Figure 11 and Figure 12). The depth, in inches, at that pressure was recorded as the depth to refusal (DTR). The penetrometer DTR is often used as an index of soil density. A denser soil is less likely to allow infiltration. Rainfall simulations conducted on roadcuts in Oregon found increased infiltration rates in soils with penetrometer depths to refusal (DTRs) greater than 4 inches.[2]

Soil Moisture

A hydrometer was used to measure volumetric soil moisture content adjacent to the penetrometer readings at a depth of 4.7 inches (12 cm) (Figure 13). An average of 30 random penetrometer readings were taken at each test plot sampled in 2005. An average of 10 random penetrometer readings and 5 soil

[2] Grismer, M. Simulated Rainfall Evaluation at SunRiver and Mt Bachelor Highways, Oregon. Unpublished.

moisture readings were taken along the same randomly located transects as were used for cover point monitoring. In 2007, penetrometer and soil moisture were taken along the same transects as the cover point measurements.

Soil moisture affects biological activity in the soil. This activity is maximized at certain moisture levels with considerable decreases in biological activity above or below those levels.[3, 4]

Figure 11. Cone penetrometer dial, showing pressure applied in pounds per square inch.

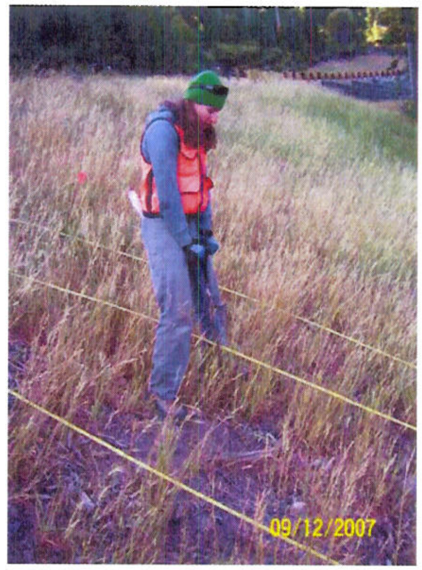

Figure 12. Conducting cone penetrometer readings along transects.

<u>Solar Exposure</u>

The Solar Pathfinder (Figure 14) was used to measure the solar radiation at three locations at the Northstar test plots (Figure 3), and three locations at the adjacent native site. Since solar input affects evaporation rates and soil temperature, which may affect time of seed germination, germination rate, rate of plant growth and soil microbial activity, it is an important variable to consider when monitoring plant growth and soil development.

---

[3] Paul E. A. and F.E. Clark. 1989. Soil Microbiology and Biochemistry. San Diego: Academic Press

[4] Allen, M.F. 1992. Mycorrhizal Functioning. NY: Chapman and Hall.

Figure 13. Conducting soil moisture readings along transects.

Figure 14. Solar pathfinder in use.

Figure 15. Soil shear strength tester.

Soil Nutrient Analysis

In 2003, prior to any treatment, ten soil samples were collected from throughout the area to be treated. Soil samples were also taken from three reference sites to the north, east, and west of the ski run. These were used as baseline soil nutrient levels. In 2006, soil samples were taken from plot 21 (6 Compost and Biosol), plot 22 (2,000 Biosol), plot 25 (Control Till), and the native plot. In 2007, soil samples were taken from three plots of each treatment type (Figure 3). In 2006, for each plot sampled, three sub-samples were taken from the mineral soil beneath any mulch layer, to a depth of 12 inches (30 cm). In 2007, only one sample was taken from each plot but samples from plots with the same treatment were combined. Once combined these sub-samples were, sieved to remove any material larger than 0.08 inches (2 mm) in diameter, and sent to A&L Laboratories (Modesto, CA) for S3C nutrient suite, total Kjeldahl nitrogen (TKN), and organic matter analysis.

Successful re-vegetation requires nutrient capital storage in the soil. Readily available sources of nitrogen must be present, and sufficient organic matter and a healthy microbial community are necessary, to provide long-term sources of nitrogen. Previous studies of soil nutrient levels at re-vegetation sites throughout the Tahoe area found that sites with high plant cover had significantly higher soil nutrients over the long-term than soils with lower soil nutrient levels.[5]

[5] Claassen, V. P. and Hogan, M. P. Soil Nutrients Associated with Revegetation of Disturbed Sites in the Lake Tahoe Basin. Restoration Ecology. 2002 Jun; 10(2):195-203.

Figure 16. Soil sub-sample collection

Rainfall Simulation

Rainfall simulation was conducted in 2006 and 2007. In both years, rainfall simulations were conducted on three plots with the following treatments: Biosol, Biosol and 6 coarse overs, Biosol and 2 compost, and Biosol and 6 compost (Figure 3). In 2006, two rainfall simulations were conducted on the tilled control plots, and one rainfall simulation was conducted on the native site. In 2007, three rainfall simulations were conducted on the tilled control plots but rainfall was not conducted again on the native site. It was assumed that the native site would not vary greatly between 2006 to 2007; therefore, it was not resampled.

The rainfall simulator "rains" on a square plot from a height of 3.3 feet (1 m) (Figure 17 and Figure 18). The rate of rainfall is controlled, and runoff is collected from a trough at the bottom of a 6.5 square feet (0.6 m^2) frame that is pounded into the ground. The volume of water collect is measured; then the volume of infiltration is calculated by subtracting the volume of runoff from the total volume of water applied to the plot. If runoff was not observed during the first 30 minutes, the simulation was stopped. The collected runoff samples are then analyzed for the amount of sediment, presented as the average sediment yield.

The cone penetrometer was used to record the DTR surrounding the runoff frames before rainfall simulations. The 2006, pre-rainfall DTR values were taken at a maximum pressure of 250 psi (1,722 kPa). In 2007, pre-rainfall DTR were taken at a maximum pressure of 350 psi (2,413 kPa), the same pressure used to sample the soil density throughout the plot. Soil moisture was also measured in each runoff frame prior to conducting the rainfall simulations. After rainfall simulation, at least three holes were dug with a trowel to determine the depth to wetting front, which shows how deeply the water infiltrated within the frame. In 2007, at least 9 holes were dug to measure the depth to wetting.

Different rainfall rates were applied to different plots depending on their propensity to runoff. In 2006, the initial rainfall rate applied to the test plots was 2.8 inches/hour (72 mm/hour). If runoff was not observed the rainfall rate was increased to 3.5 inches/hour (90 mm/hour), and then to 4.7 inches/hour (120 mm/hour) until runoff was observed or all the water was infiltrated onsite. In 2007, the same initial rainfall rate was applied to the test plots (2.8 inches/hour), but if runoff was not observed, the rainfall rate was immediately increased to 4.7 inches/hour (120 mm/hour) until runoff was observed or all rainfall was infiltrated. The 2007 initial rainfall rate of 2.8 inches per hour is more than twice the intensity of the 20 year, 1 hour "design storm" for the local area.

Figure 17. Rainfall simulator and frame.

Figure 18. Rainfall simulator at Northstar test plots, 2006.

Statistical Analysis

An analysis of variance test (ANOVA), which compares average values between two or more different groups, was used to resolve differences between plant cover values by treatment type, amendment type, and fertilizer (Biosol) application.

If a difference was detected using the ANOVA test, the Mann-Whitney test was used to further investigate differences between two sub-groups or sample sets within the larger group. For example, the Mann-Whitney was used to further investigate differences in plant cover by amendment application. The no till plots without amendments and tilled plots with amendments were compared. The Mann-Whitney test is a non-parametric test that can be applied to data sets with non-normal distributions. Non-normal distributions are common within small data sets. At the Northstar test plots, most of the treatments only have three replications (n=3). The term significance was not used unless results were proven significant using a statistical test.

RESULTS/DISCUSSION

Rainfall

Tilled treatment plots with and without amendments produced 91% less sediment than comparable surface treatment plots at Northstar. A hydroseeded surface treatment site in the Big Springs neighborhood at Northstar produced 812 lbs/acre/in (358 kg/ha/cm), while the highest sediment yield from the tilled treated plots over two years was 66.7 lbs/acre/in (26.9 kg/ha/cm) at the plot with Biosol only (Figure 19 and Figure 20). In comparison, the native reference plot had a sediment yield of 6.8 lbs/acre/in (3.0 kg/ha/cm).

In 2006 and 2007, treatment plots with 6 inches of either compost or coarse overs produced the least amount of sediment. These plots produced 2% of the sediment compared to that produced at the untreated site (Figure 19 and Figure 20). These lower sediment yields are most likely due to a higher proportion of soil amendment per tilling volume, which should lower soil density and allow more infiltration.

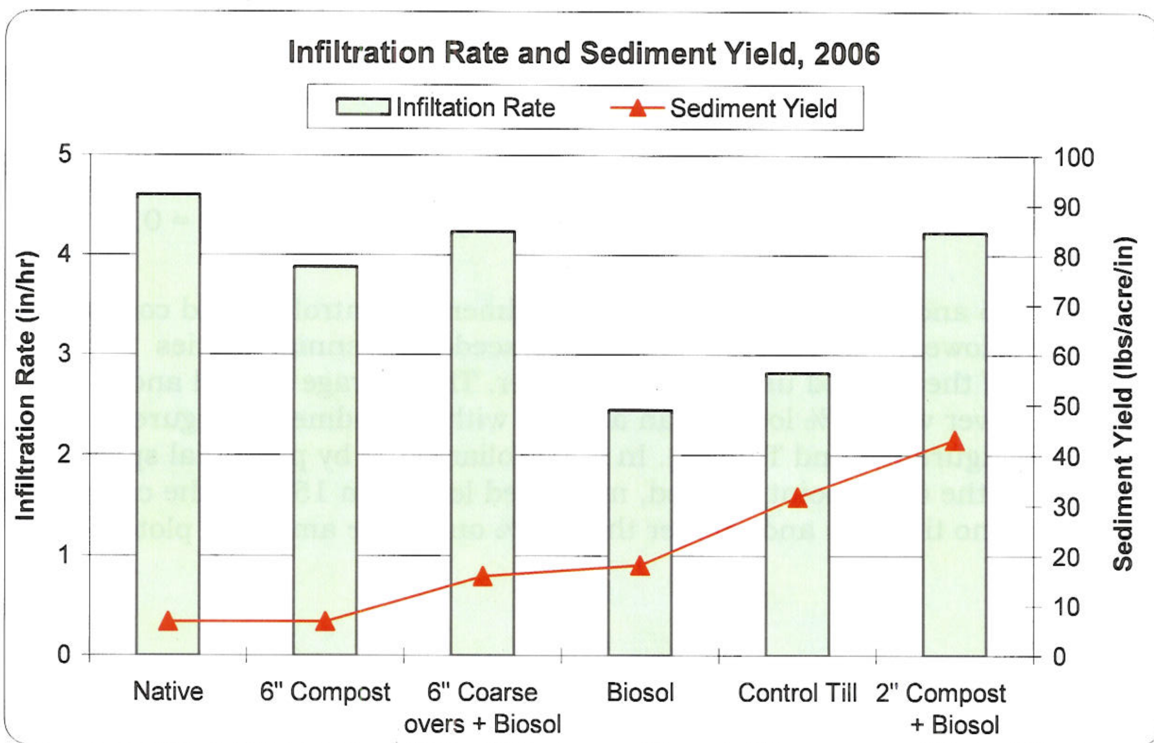

Figure 19. Infiltration Rate and Sediment Yield, 2006. Plots receiving 6 inches of amendment produced lower sediment yields than plots receiving other treatments.

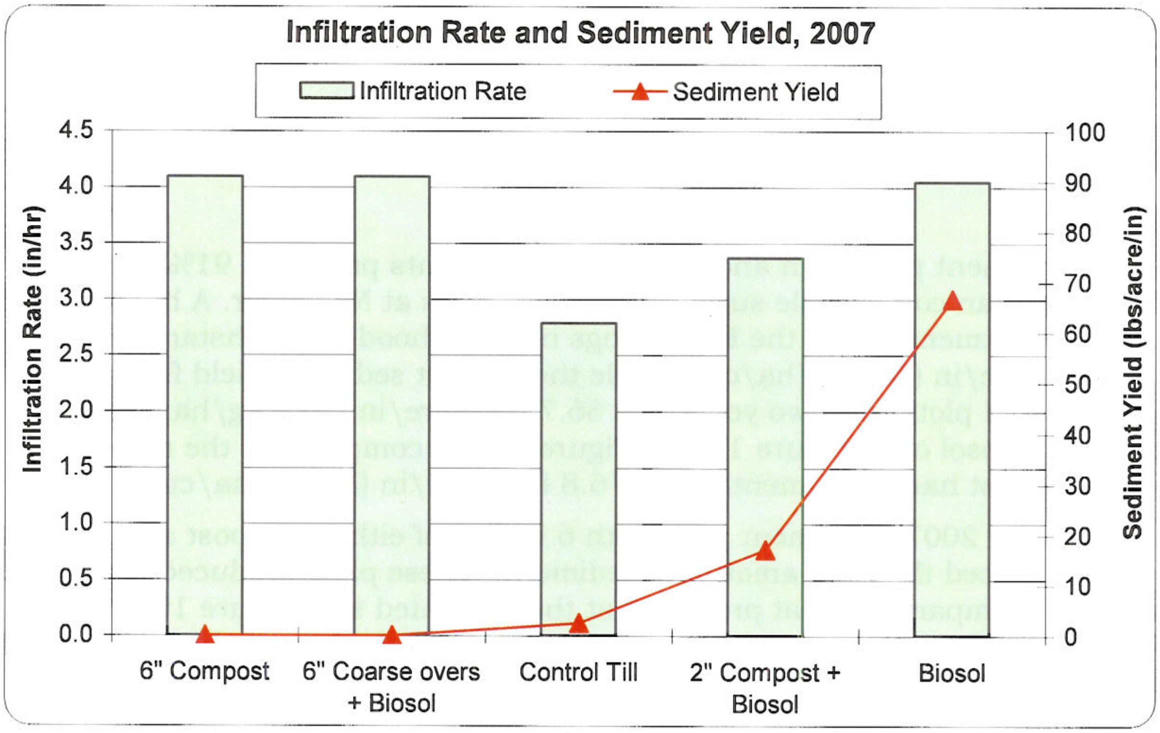

Figure 20. Infiltration Rate and Sediment Yield, 2007. Plots receiving 6 inches of amendment produced no runoff or sediment yields compared to plots receiving other treatments.

Plant Cover and Composition

Perennial native plants have deep and extensive root systems, which increase soil strength. In 2006, higher perennial plant cover, assessed by ocular estimation, was correlated with lower sediment yields $R^2 = 0.66$, $p = 0.10$ (Figure 21).

In both 2006 and 2007, plots without amendments (control till and control no till) had the lowest plant cover and cover by seeded perennial species regardless of the method used to assess cover. The average seeded and perennial cover was 50% lower than at plots with amendments (Figure 22, Figure 23, Figure 24, and Table 3). In 2007 foliar cover by perennial species, recorded by the cover point method, measured less than 15% on the control till and control no till plots and greater than 20% on all the amended plots.

Of the amended plots, those with compost had 1.35 times more total plant cover (greater than 27%) and 1.25 more cover by perennial species (greater than 25%) than plots amended with coarse overs. Plots with coarse overs had less than 20% total cover and cover by perennials, as measured by cover point (Figure 22, Figure 23 and Table 3). Plots with Biosol only had higher perennial plant cover than tilled plots without amendments or Biosol, approximately 1.8 times more cover (Figure 23).

Total plant cover on the treated plots decreased between 2006 and 2007 (Figure 22). A decrease was also observed at the untilled control plot, from 42% to 30%. A small increase in total plant cover, 30% to 38%, was observed at the control plot that received tilling. The decrease in plant cover was most likely due to the low annual precipitation recorded during the 2006-2007 water year.

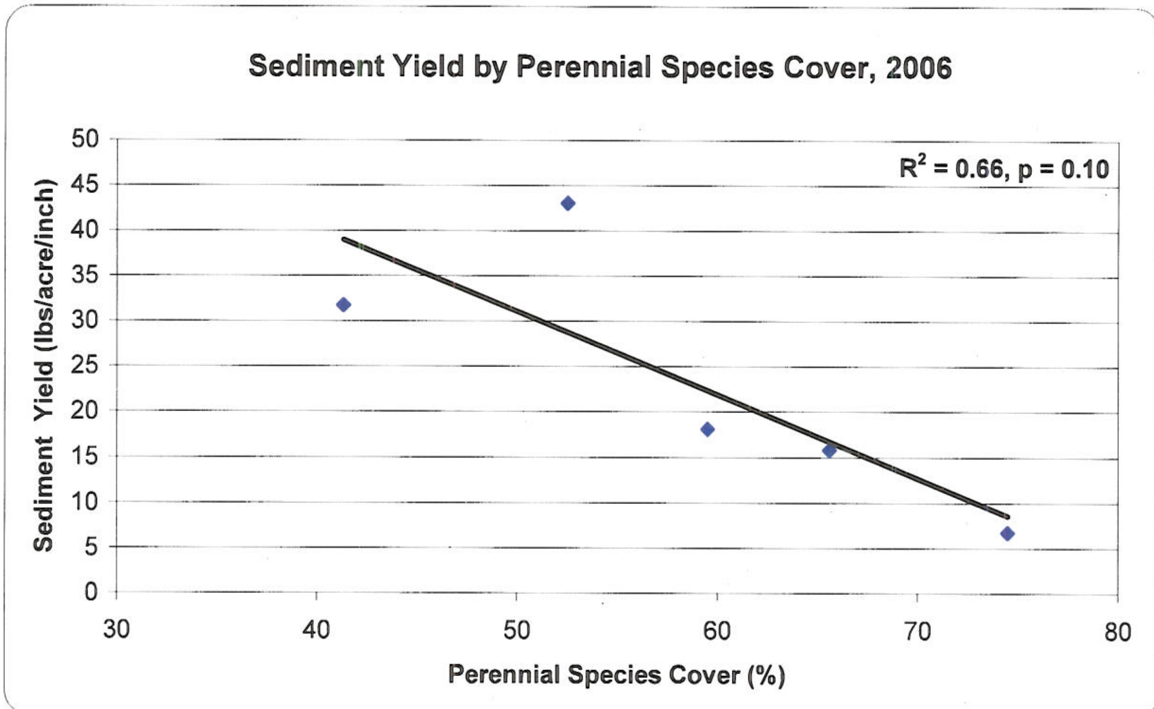

Figure 21. Sediment Yield by Perennial Species Cover, 2006. Plots with higher perennial plant cover produce less sediment than plots with lower perennial plant cover. Perennial species cover determined by ocular estimates. $R^2 = 0.66$, $p = 0.10$

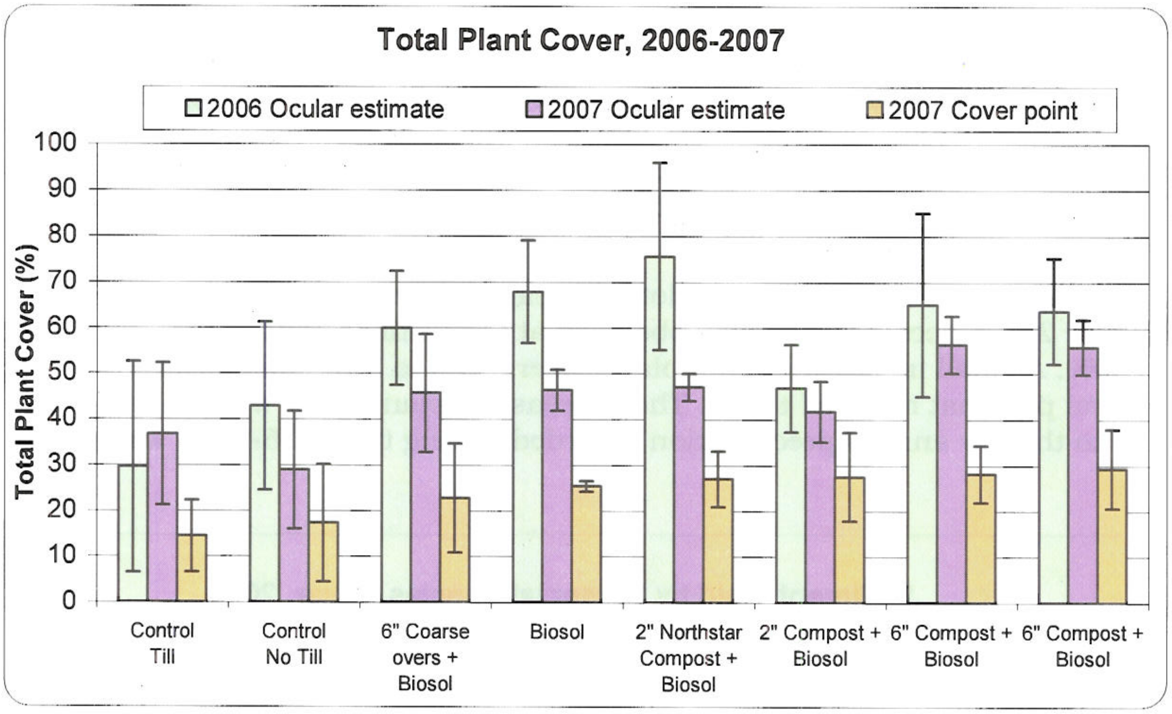

Figure 22. Total Plant Cover, 2006-2007. Plots with no amendments (control till and control no till) exhibited the lowest plant cover. Total plant cover on the treated plots decreased from 2006 to 2007. Error bars denote one standard deviation above and below the mean.

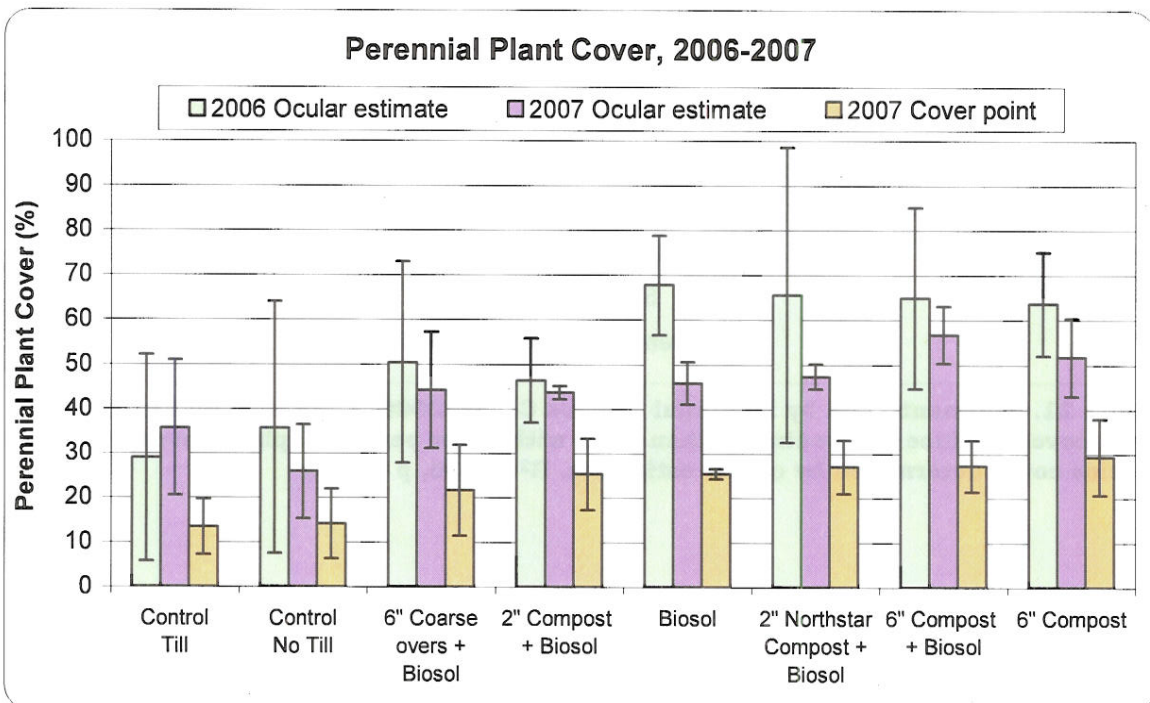

Figure 23. Perennial Plant Cover, 2006-2007. Plots with no amendments (control till and control no till) exhibited the lowest cover by perennial species. Error bars denote one standard deviation above and below the mean.

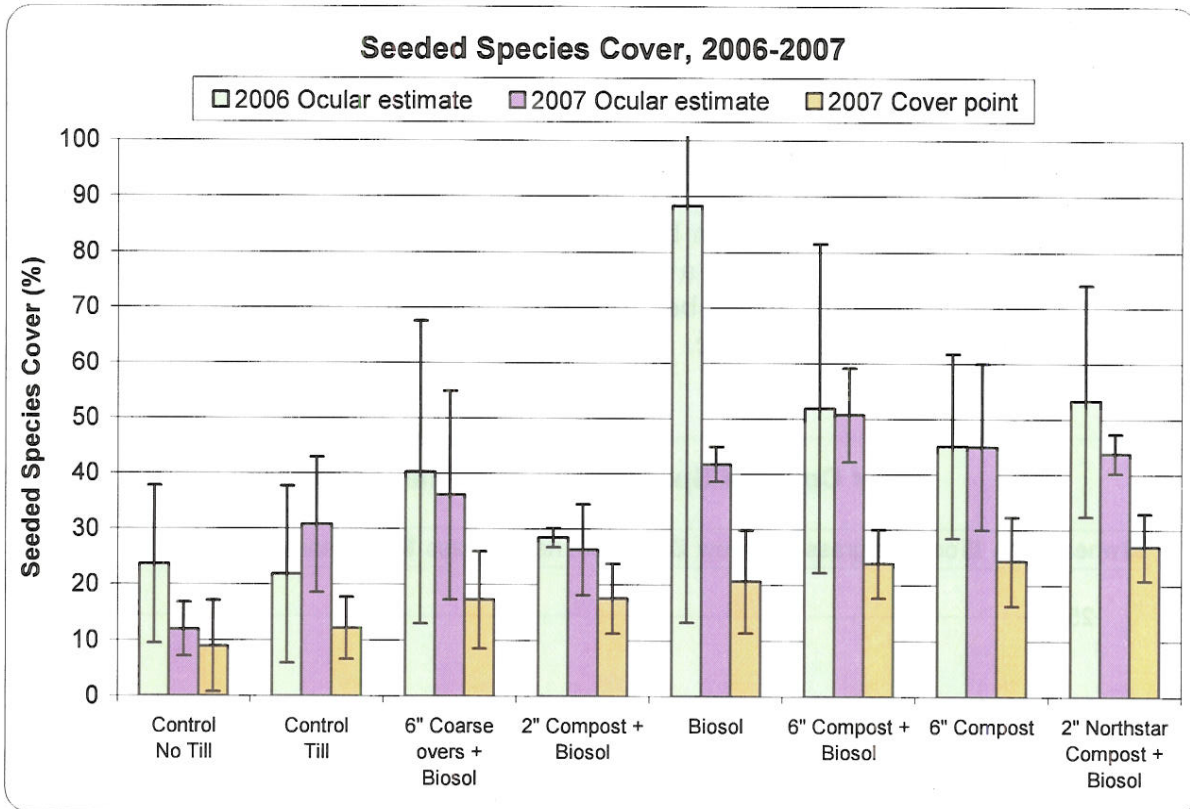

Figure 24. Seeded Species Cover, 2006-2007. Plots with no amendments (control till and control no till) exhibited the lowest cover by seeded perennial species. Error bars denote one standard deviation above and below the mean.

In both 2006 and 2007, seeded perennial species composed the majority of plant cover.

In 2006 and 2007, tilled plots with amendments produced statistically higher cover by squirreltail than plots without amendments. In 2007, these plots had 1.7 to 2 times more cover than tilled plots without amendments and almost 10 times more cover than no till plots (Figure 25 and Table 3). Squirreltail cover was highest on the plots with compost, 13.6% to 18.6%, compared to only 7% cover on the plot with coarse overs and 1% cover on the no till plot. In 2007, squirreltail was the dominant species at the test plots (7% to 18.6%, Figure 25). Cover by squirreltail was not adversely affected by the low precipitation in 2007.

Cover by Western needlegrass was highest on tilled plots, 2 -3 times higher than on no till plots (Figure 25 and Table 3). Cover by Western needlegrass ranged from 5 to 9% on the tilled plots with amendments, averaged 11% on tilled plots without amendments (with or without Biosol), and averaged 3.1% on the no till plots Figure 25 and Table 3). Cover by Western needlegrass was 2 times higher on tilled plots without amendments, with or without Biosol, than needlegrass on plots with compost was 6.6%, on plots with coarse overs cover was 9%, on tilled plots without amendments cover was 11.3%, and on plots without tilling cover was 3.1% (Figure 25 and Table 3). Cover by Western needlegrass was about 10% in both 2006 and 2007, indicating its resilience in a low water year.

Mountain brome, which was the dominant species in 2006, represented less than 5% of the cover for any given treatment in 2007 (Figure 25, Appendix A). A decrease in cover by mountain brome was observed throughout the Tahoe area in 2007, and is most likely a response to low annual precipitation. Blue wild rye was not present, either because it did not germinate, or because the site conditions were unfavorable.

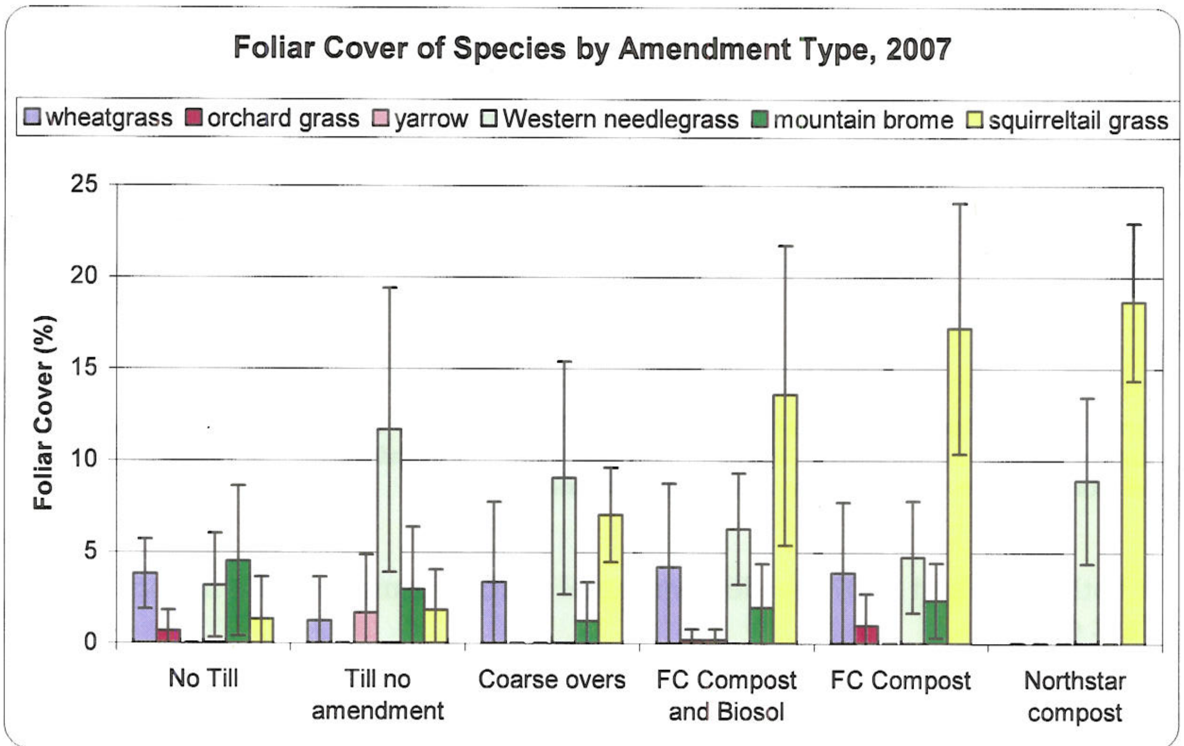

Figure 25. Cover by Foliar Species by Amendment Type, 2007. Tilled plots with amendments produced statistically higher cover by squirreltail than no till plots or tilled plots without an amendment. Error bars denote one standard deviation above and below the mean. FC Compost = Full Circle Compost.

Table 3. Mann-Whitney test results for Plant Cover and Composition, 2006 and 2007.

Variable tested	Factor tested and sample size	U-value and p-value
2006 Seeded species	Till (n=24)> No till (n=3)	U = 54.5, p=0.162
2007 Seeded species	Till (n=24)> No till (n=3)	U = 63, p=0.036
2006 Plant cover	Amendment (n=18) > No till (n=3)	U = 43.5, p=0.125
2006 Perennial cover	Compost (n=3) > No till (n=3)	U = 8, p= 0.2
2006 Perennial cover	Compost (n=3) > Till no amendment (n=3)	U = 8, p= 0.2
2006 Perennial cover	Compost and Biosol (n=6) > Till no amendment (n=3)	U = 16, p=0.095
2006 Perennial cover	2K Biosol (n=3) > No till (n=3)	U = 8, p= 0.2
2006 Perennial cover	2K Biosol (n=3) > Till no amendment (n=3)	U = 8.5, p=0.1
2006 Squirreltail grass	Amendment (n=18) > No till (n=3)	U = 43.5, p=0.125
2006 Squirreltail grass	Amendment (n=18) > Till no amendment (n=6)	U = 76, p=0.156
2006 Western needlegrass	Amendment (n=18) > No till (n=3)	U = 40.5, p=0.185
2006 Western needlegrass	2K Biosol (n=3) > No till (n=3), 2K Biosol & Compost	U = 9, p=0.1
2007 Plant cover	Amendment (n=18) > No till (n=3)	U = 42, p=0.153
2007 Plant cover	Amendment (n=18) > Till no amendment (n=6)	U = 81, p=0.077
2007 Perennial cover	Amendment (n=18) > Till no amendment (n=6)	U = 83, p=0.056
2007 Perennial cover	Amendment (n=18) > No till (n=3)	U = 42, p=0.153
2007 Seeded species	Amendment (n=18) > Till no amendment (n=6)	U = 75, p=0.177
2007 Seeded species	Amendment (n=18) > No till (n=3)	U = 50, p=0.017
2007 Squirreltail grass	Amendment (n=18) > Till no amendment (n=6)	U = 103, p=0.0003
2007 Squirreltail grass	Amendment (n=18) > No till (n=3)	U = 85, p=0.001
2007 Western needlegrass	Amendment (n=18) > No till (n=3)	U = 42.5, p=0.125
2007 Western needlegrass	Till no amendment (n=6) > Amendment (n=18)	U = 74.5, p=0.177

Soil Density

Penetrometer depths to refusal (DTRs) at tilled plots were 1.5 to 4 times deeper than DTRs at untilled plots in both 2006 and 2007 ($p<0.05$). The DTR of tilled plots decreased from 7.1 in (18 cm) in 2006 to 4 in (10.2 cm) in 2007.

In 2007, plots without organic amendments exhibited shallower DTRs, 2.5 to 3 inches (6.4 to 7.6 cm) when compared to plots with amendments, 3.5 to 5 inches (8.9 to 12.7 cm) (Figure 26).

In 2006 the penetrometer DTRs at plots with coarse overs were 1.3 to 1.5 inches deeper than DTRs at plots with other amendments. Plots with coarse overs had an average DTR of 9.4 inches (23.9 cm) as compared to 6.2 to 7.3 for other amendments (Figure 26). The average penetrometer DTR at the native site was similar to all plots with amendments, at 6.9 inches (17.5 cm).

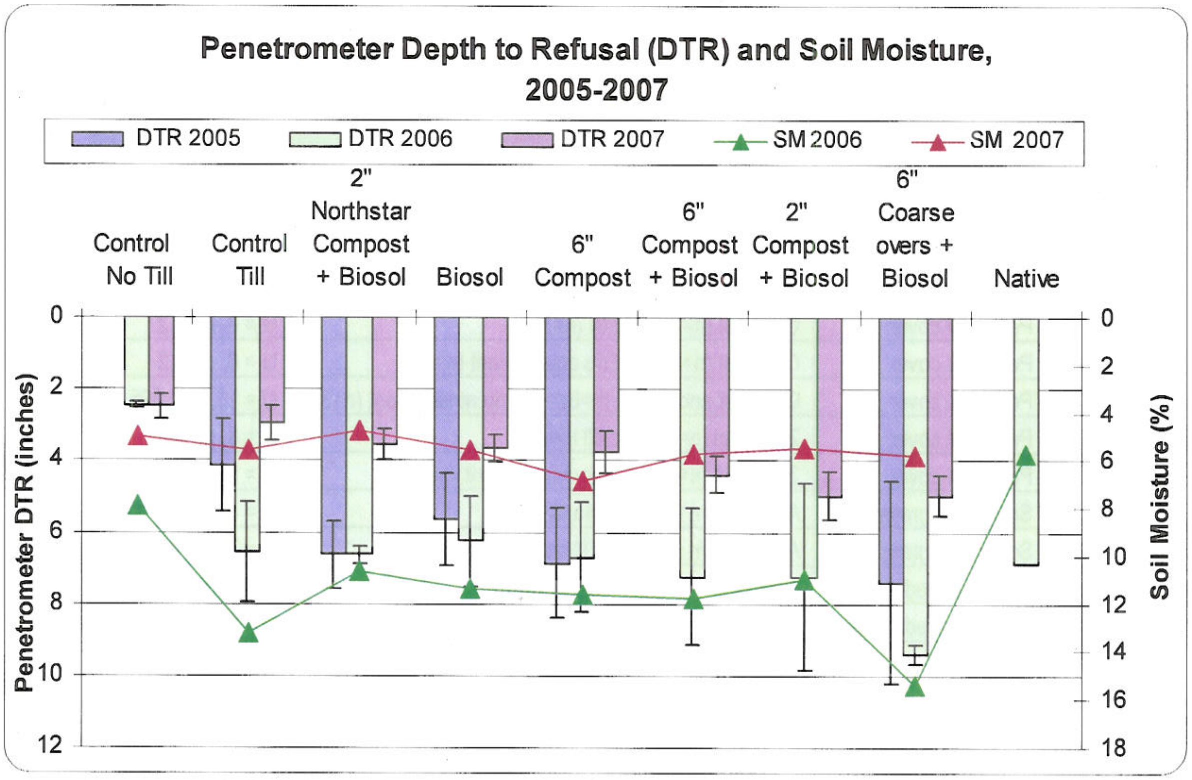

Figure 26. Penetrometer Depth to Refusal (DTR) and Soil Moisture, 2005-2007. Deepest penetrometer values in 2005 and 2006 were measured at the plots amended with coarse overs. Error bars denote one standard deviation above and below the mean.

Soil Moisture

In 2006, the soil moisture at the tilled plots was higher than that at the no till plots and ranged from 10.7% to and 15.4% versus 7.9% at the no till plots (Figure 26). In 2007, soil moisture was lower at tilled sites, 4.8% to 6.8%, when compared to 2006. The no till plots also decreased between 2006 and 2007 to 4.9%. The higher soil moisture values in 2006 were most likely due to recent rainfall. Soil moisture values recorded at the Northstar Lookout Mountain site are within the normal range for volcanic soils in the Tahoe area.

Soil Nutrients

The TKN for plots with coarse overs, 1,394 ppm, was similar to the TKN values recorded for plots with compost, 1,080 to 2,037 ppm. The average TKN at plots amended with compost or coarse overs was 1,997 ppm in 2006 and 1,573 ppm in 2007. These values were on average 60% higher than pre-treatment TKN, 1,061 ppm, and TKN measured at a nearby native site, 1,147 ppm (Figure 27 and Figure 28). The lowest TKNs were observed at the control till plot without amendment or Biosol (1,000 ppm) and the control no till plot (1,250 ppm). Plots with Biosol only had about 1.3 times higher organic matter and TKN than control till plots without Biosol and similar organic matter and TKN to plots with amendments.

In both 2006 and 2007, the control till plot had the lowest percentage of organic matter, less than 4%. The plots with amendments had between 4.8 and 7% organic matter in 2006 and 2007, similar to that of the native site. The plot with Biosol but no organic amendment was only sampled in 2006, and had the highest percentage of organic matter, 7.8%. This is most likely a result of the pre-treatment nutrient variation, rather than the treatment effects. The control no till plot was only sampled in 2007, at that time it had 4.9% organic matter. Organic matter content for the plots amended with coarse overs was 5.9%, similar to the percentage organic matter in the compost plots, which ranged from 4.7% to 6.7%.

Overall, the results of the soil nutrient testing have shown that the higher soil TKN and organic matter in the amended plots supports more plant growth. The exception is the no till plots, which did not support increased total plant cover or cover by desirable, perennial species (Figure 22 and Figure 23), but did have higher TKN and organic matter.

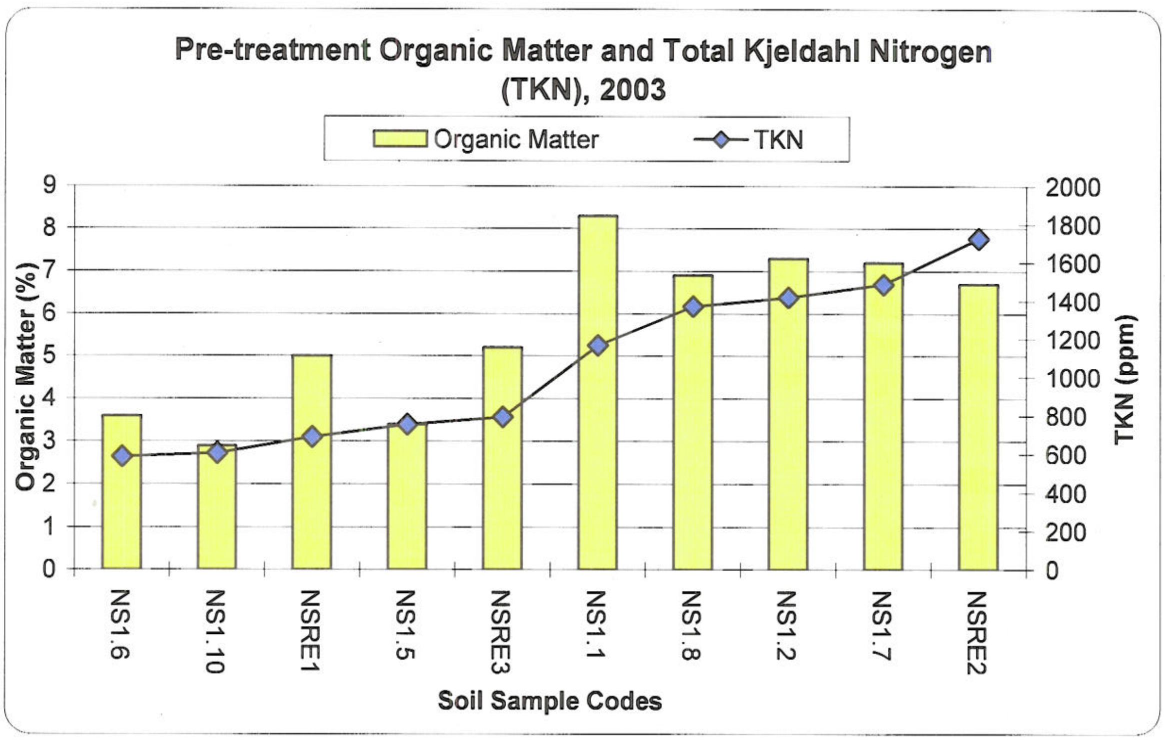

Figure 27. Pre-treatment Organic Matter and Total Kjeldahl Nitrogen (TKN), 2003. On average TKN for the plots with compost was 60% higher than for the native site or test site pre-treatment.

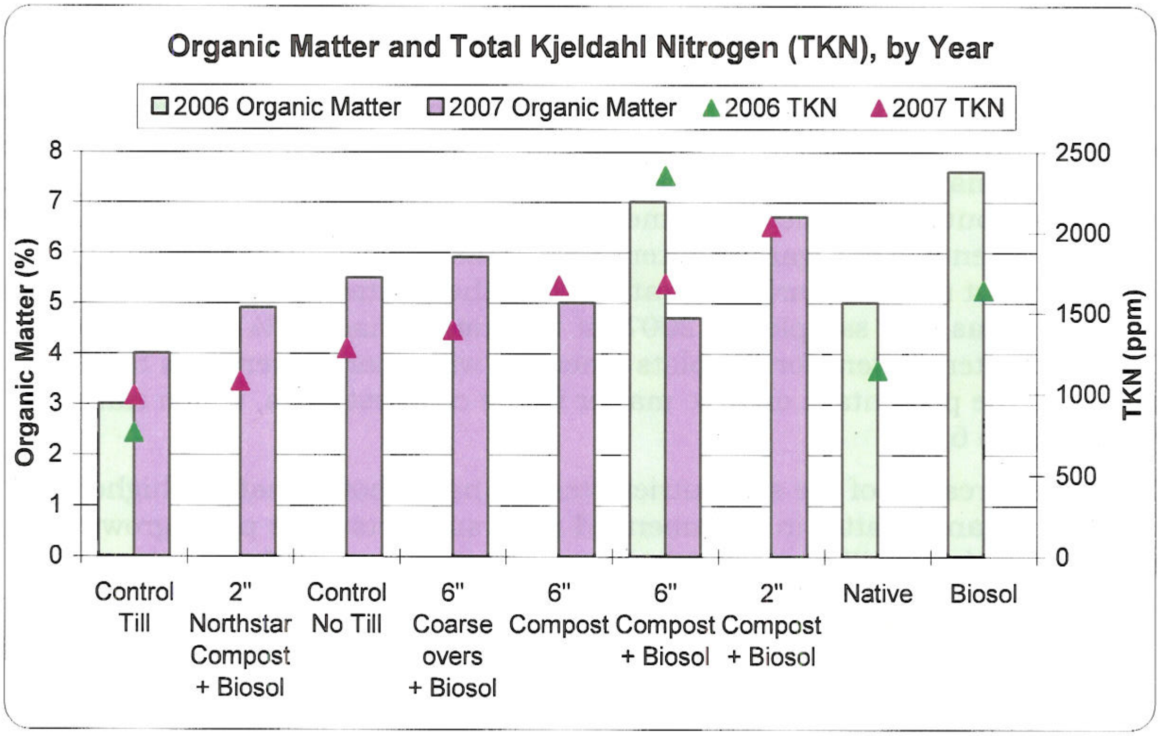

Figure 28. Organic Matter and Total Kjelhdahl Nitrogen (TKN), by Year. On average TKN for the plots with compost was 60% higher than for the native site or test site pre-treatment.

Solar Radiation

The mean solar radiation, or solar exposure is 93%. There are small variations in solar radiation among the test plots. Plots on the edges, closer to the forest, received more shade and had lower solar exposure. This may have a small affect on plant growth, species composition, and soil moisture, but no pattern was detected during the sampling.

CONCLUSIONS

Infiltration

- Tilled treatment plots with and without amendments produced 91% less sediment than comparable surface treatment plots at Northstar.
- In 2006 and 2007, treatment plots with 6 inches of either compost or coarse overs produced the least amount of sediment. They produced only 2% of the sediment produced at the untreated site (Figure 19 and Figure 20).

Plant Cover

- In 2006, higher perennial plant cover, assessed by ocular estimation, was correlated with lower sediment yields $R^2 = 0.66$, $p = 0.10$ (Figure 21).

- In both 2006 and 2007 plots without amendments (control till and control no till) had the lowest plant cover and cover by seeded species regardless of the method used to assess cover. The average perennial and seeded cover was 50% lower that at plots with amendments (Figure 22, Figure 23, Figure 24, and Table 3).
- Of the amended plots, those with compost had 1.35 times more total plant cover (greater than 27%) and 1.25 more cover by perennial species (greater than 25%) than plots amended with coarse overs. Plots with coarse overs had less than 20% total cover and cover by perennials, as measured by cover point (Figure 22, Figure 23, and Table 3).
- Plots with Biosol only had higher perennial plant cover than tilled plots without amendments or Biosol, approximately 1.8 times more cover (Figure 23).

Plant Composition

- In both 2006 and 2007 seeded perennial species composed the majority of plant cover.
- In 2006 and 2007, tilled plots with amendments produced statistically higher cover by squirreltail than plots without amendments. In 2007, these plots had 1.7 to 2 times more cover than tilled plots without amendments and almost 10 times more cover than no till plots (Figure 25 and Table 3).
- Squirreltail produced the highest cover on plots with compost, 13.6% to 18.6%, compared to only 7% cover on the plot with coarse overs and 1% cover on the no till plot.
- Cover by squirreltail was not adversely affected by the low precipitation in 2007.
- Cover by Western needlegrass was 2 times higher on the tilled plots without amendments, with or without Biosol, than tilled plots with amendments and was not adversely affected by the low precipitation in 2007 (Figure 25).
- Cover by Western needlegrass was highest on tilled plots, 2 -3 times higher than on no till plots.
- Mountain brome, which was the dominant species in 2006, represented less than 5% of the cover for any given treatment in 2007 (Figure 25, Appendix A).
- Blue wild rye was not present, either because it did not germinate, or because the site conditions were unfavorable.

Soil Density

- Penetrometer depths to refusal (DTRs) at tilled plots were 1.5 to 4 times deeper than DTRs at untilled plots in both 2006 and 2007 ($p<0.05$).
- In 2007, plots without organic amendments exhibited shallower DTRs, 2.5 to 3 inches (6.4 cm to 7.6 cm) when compared to plots with amendments, 3.5 to 5 inches (8.9 to 12.7 cm) (Figure 26).
- In 2006, penetrometer DTRs at the plots with coarse overs were 1.3 to 1.5 inches deeper than DTRs at plots with other amendments. Plots with coarse overs had an average DTR of 9.4 inches (23.9 cm) as compared to 6.2 to 7.3 for other amendments (Figure 26).
- DTR of tilled plots decreased from 7.1 inches (18 cm) in 2006 to 4 in (10.2 cm) in 2007.

Soil Nutrients

- TKN for the plots with coarse overs, 1,394 ppm, was similar to the TKN values recorded for plots with compost, 1,080 to 2,037 ppm.
- The average TKN at plots amended with compost or coarse overs was 1,997 ppm in 2006 and 1,573 ppm in 2007. These values were on average 60% higher than pre-treatment TKN, 1,061 ppm, and TKN measured at a nearby native site, 1,147 ppm.
- The plots with amendments had between 4.8 and 7% organic matter in 2006 and 2007, similar to that of the native site.
- Organic matter content for the plots amended with coarse overs was 5.9%, similar to the percentage of organic matter in the compost plots, which ranged from 4.7% to 6.7%.
- Plots with Biosol only had about 1.3 times higher organic matter and TKN than control till plots without Biosol and similar organic matter and TKN to plots with amendments.

Soil Moisture

- The soil moistures levels are within those observed as a normal soil moisture level in local volcanic soils.

RECOMMENDATIONS

These recommendations are for north facing slopes with rocky soils derived from volcanic parent material, with high summer solar exposures, slope angles of approximately 30 degrees, situated at an elevation of 6,721 feet (2,049 m):

Tilling: 18 inches

Amendment: 6 inches compost (25% fines and 75% coarse overs) at approximately 5,352 lbs/acre (6,000 kg/ha) of nitrogen equivalent

Biosol: 1,784 lbs/acre (2,000 kg/ha)

Seed: 125 lbs/acre (140 kg/ha) seed with the following composition:

50% squirreltail
30% Western needlegrass
20% mountain brome

Mulch: 2 inches of pine needle mulch

Soil Loosening versus No Soil Loosening

Tilling is recommended over no tilling for the following reasons:

- Tilled treatment plots produced 91% less sediment than surface treatment plots at Northstar.
- Penetrometer depths to refusal (DTRs) at tilled plots were 1.5 to 4 times deeper than DTRs at untilled plots in both 2006 and 2007 ($p<0.05$).
- Cover by Western needlegrass, the dominant seeded species was 3.6 times higher on tilled plots without an amendment or biosol than on untilled plots.

Amendment versus No Amendment

An organic amendment incorporated into the soil is recommended for the following reasons:

- The average TKN values at plots with compost or coarse over amendments were 60% higher than pre-treatment TKN (1,061 ppm) and native TKN (1,147 ppm).
- In 2006 and 2007, tilled plots with amendments produced 2 to 9 times more cover by squirreltail, the dominant grass, than plots without an amendment. In 2007, these plots had 1.7 to 2 times more cover than tilled plots without amendments and almost 10 times more cover than no till plots without amendments.
- The plots with amendments had between 4.8 and 7% organic matter in 2006 and 2007, similar to that of the native site.
- In 2007, plots without organic amendments exhibited shallower DTRs, 2.5 to 3 inches (6.4cm to 7.6cm) when compared to plots with amendments, 3.5 to 5 inches (8.9 cm to 12.7).

Amendment Type and Rate (6 inches compost, 2 inches Northstar compost, or 6 inches coarse overs)

The Full Circle compost with 75% fines and 25% coarse overs should be applied at 6 inches for the following reasons. The Full Circle compost is recommended over the Northstar compost, since the nutrient content and coarse and fine material in the Northstar compost are not known and therefore cannot be recommended. The reasons are as follows:

- In 2006, the penetrometer DTRs at the plots with coarse overs were 1.3 to 1.5 inches deeper than DTRs at plots with other amendments, 9.4 inches for coarse overs as compared to 6.2 to 7.3 for other amendments.
- Of the amended plots, those with compost had 1.35 times higher total plant cover (greater than 27%) and 1.25 higher cover by perennial species (greater than 25%) than plots amended with coarse overs.
- In 2006 and 2007, treatment plots with compost produced only 2% of the sediment of the untreated site. This performance was similar to that of the sites with Northstar compost or coarse overs.
- Squirreltail, a beneficial native, perennial species, produced more than 2 times the cover on plots with compost, 13.6% to 18.6%, compared to plots with coarse overs.
- The plots with compost had TKN levels that were similar to the plots amended with coarse overs. These values were on average 60% higher than pre-treatment TKN, 1,061 ppm and TKN measured at a nearby native site of 1,147 ppm.

Biosol Rate

Biosol is recommended at the applied rate of 1,784 lbs/acre (2,000 kg/ha) for the following reasons:

- Plots with Biosol had about 1.3 times higher organic matter and TKN than control till plots without Biosol and similar organic matter and TKN to plots with amendments.
- The plots with Biosol had 1.8 times higher perennial plant cover than control till plots without Biosol.

Seed Rate and Composition

Seed should be applied at a rate of 125 lbs/acre (140 kg/ha) with the following composition:

50% squirreltail
30% Western needlegrass
20% mountain brome

This compostition is recommended over the tested composition (29% mountain brome, 27% squirreltail, 25% blue wild rye, and 13% Western needlegrass). The reasons for the recommendation are as follows:

- In both 2006 and 2007, seeded perennial species composed the majority of plant cover, greater than 80%.
- Blue wild rye was not present, either because it did not germinate, or because the site conditions were unfavorable. Therefore, removal from the seed mix is recommended.
- In 2006, higher perennial plant cover, assessed by ocular estimation, was correlated with lower sediment yields. Therefore, it is recommended that the mix is still composed of mostly native, perennial grasses.
- Mountain brome, which was the dominant species in 2006, represented less than 5% of the cover for any given treatment in 2007 (Figure 25, Appendix A). This fluctuation is most likely a result of the low precipitation in 2007. The recommended percent (20%) is less than tested to ensure less fluctuation in plant cover during drought years.
- Squirreltail composed between 2 and 3 times more plant cover than other species on compost plots in 2007. Its proportion in the seed mix was increased from 27% to 50% because it was able to thrive during a drought year (2007).
- Western needlegrass was not adversely affected by the low precipitation in 2007. Therefore, higher proportions of these grasses than were tested are recommended since it will thrive during drought years.

Mulch Cover and Depth

Mulch composed of local pine needles should be applied to a depth of 2 inches and a cover of at least 99% for the following reasons:

- With a 1 inch mulch application, cover after three years only remained at a ½ to ¾ inch depth.

Appendix A

2006 Species List for Northstar long term plots. T = trace amounts of cover

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Noxious/ Invasive	Phenology	Ocular Estimate (%)																											
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Native
Forb	Asteraceae	Achillea millefolium	yarrow	Perennial	Native		Veg					T	< 5	T		< 5					T		T	T	T			T	T	T		T		T	
Forb	Chenopodiaceae	Chenopodium albens	goosefoot	Annual	Alien		Seed							T																					
Forb	Asteraceae	Cirsium andersonii	Anderson's thistle	Perennial	Native		Flower																												
Forb	Polemoniaceae	Collomia linearis	linear leaf collomia	Annual	Native		Dry						T																						
Forb	Polemoniaceae	Collomia tinctoria	tinted collomia	Annual	Native		Flower																												
Forb	Polygonaceae	Eriogonum nudum	nude buckwheat	Perennial	Native		Veg																									T			
Forb	Polygonaceae	Eriogonum spergulinum	spurry buckwheat	Annual	Native		Flower																												
Forb	Polygonaceae	Eriogonum umbellatum	sulfur flower	Perennial	Native		Veg																												
Forb	Brassicaceae	Erysimum capitatum	Western wallflower	Perennial	Native		Flower																												
Forb	Onagraceae	Gayophytum diffusum	prarie smoke	Perennial	Native		Flower	T							5	20						T	20	T	15 - 25			T			T		T	20	
Forb	Asteraceae	Heliomeris multiflora	showy goldeneye	Perennial	Native		Seed																								T				
Forb	Asteraceae	Lactuca serriola	devil's lettuce	Annual	Alien	Invasive	Veg																												
Forb	Brassicaceae	Lepidium campestre	English pepperweed	Annual	Alien		Seed											T																	
Forb	Linaceae	Linum lewisii	flax	Perennial	Native		Seed																			T									
Forb	Fabaceae	Lotus purshianus	Spanish lotus	Perennial	Native		Flower																												
Forb	Fabaceae	Lupinus argenteus	silver lupine	Perennial	Native		Seed					T																							
Forb	Fabaceae	Lupinus lepidus (culbertsonii)	Culberton's lupine	Perennial	Native		Seed				< 5										T														
Forb	Onagraceae	Oenethera sp.	evening primerose	Perennial	Native		Veg																												
Forb	Scrophulariaceae	Penstemon newberryi	pride of the mountain	Perennial	Native		Flower																												
Forb	Scrophulariaceae	Penstemon sp.	penstemon	Perennial	Native		Flower																T	T	T								T	T	
Forb	Hydrophyllaceae	Phacelia hastata	silverleaf phacelia	Perennial	Native		Veg															T									T				
Forb	Polemoniaceae	Phlox gracilis	slender phlox	Annual	Native		Dry																												
Forb	Polygonaceae	Polygonum arenastrum	common knotweed	Annual	Native		Flower																		10 - 15										
Forb	Brassicaceae	Sisymbrium altissimum	tumble mustard	Annual	Alien		Seed																												
Forb	Asteraceae	Taraxacum officinale	dandelion	Annual	Alien	Invasive	Veg																							T					
Forb	Asteraceae	Tragapogon dubius	false salsify	Annual	Alien		Seed																		T										
Forb	Fabaceae	Trifolium pratense	red clover	Perennial	Alien		Flower											T																	
Forb	Fabaceae	Trifolium repens	white clover	Perennial	Alien		Veg																								T				
Forb	Scrophulariaceae	Verbascum thapsis	mullen	Annual	Native	Invasive	Flower					T																T						T	
Graminoid	Poaceae	Achnatherum occidentalis	Western needlegrass	Perennial	Native		Seed	5	5 - 10	5	15	25		20	5 - 10	10 - 20	5 - 10	5	5	25	T	15	25	15	10	10	< 5	5	15 - 20	< 5	15	5 - 10	15	T	
Graminoid	Poaceae	Agropyron intermedium	intermediate wheatgrass	Perennial	Alien		Seed	20 - 25	30	10 - 15		T		T	10 - 15	5	20 - 25	5 - 10	20 - 25	5	10		T	15	< 5	10	20	10 - 20		10	5 - 10	T	5	5 - 10	
Graminoid	Poaceae	Bromus carinatus	mountain brome	Perennial	Native		seed	10 - 15	10 - 15	25 - 30	25	10 - 15	< 5	< 5	T		20 - 25	10 - 15	20 - 25	20	5 - 10	T	10			20	15	10 - 20	35	20 - 25	5		T	T	
Graminoid	Poaceae	Bromus inermis	smooth brome	Perennial	Alien		Seed					T			T	5			T							5		5		T		T	5	T	
Graminoid	Poaceae	Bromus tectorum	cheatgrass	Annual	Alien	Invasive	Seed																												
Graminoid	Cyperaceae	Carex rossii	Ross' sedge	Perennial	Native		Veg																												
Graminoid	Cyperaceae	Carex sp.	sedge	Perennial	Native		Flower																												
Graminoid	Poaceae	Dactylis glomerata	orchard grass	Perennial	Alien	Invasive	Veg	< 5	T	T		T			5						T	T	5 -	5	T						5	5	5	< 5	

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Noxious/ Invasive	Phenology	Ocular Estimate (%)																											
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Native
																							10												
Graminoid	Poaceae	Deschampsia elongata	elongated hairgrass	Perennial	Native		Seed																												
Graminoid	Poaceae	Elymus elymoides	squirrel's tail grass	Perennial	Native		Flower	10		10 - 15	25	20 - 25	5 - 10	60 - 65	5 - 10	10	10 - 15	10	10 - 15	25 - 30	5 - 10	65 - 70	35	15	20	10	10 - 15		15 - 20	35 - 40	40	5 - 10	30	10	
Graminoid	Poaceae	Elymus glaucus	blue wildrye	Perennial	Native																														
Graminoid	Poaceae	Festuca	Fescue	Perennial	Native		Veg.																												
Shrub	Rhamnaceae	Ceanothus prostratus	Squaw carpet	Perennial	Native		Veg.																			T									
Shrub	Rhamnaceae	Ceanothus velutinus	tobacco brush	Perennial	Native		Veg.	T	T	5 - 10																						T			
Shrub	Fagaceae	Chrysolepis sempervirens	Chinquapin	Perennial	native																														30
Shrub	Grossulariaceae	Ribes cereum	wax leaf currant	Perennial	Native		Veg.																												
Tree	Pinaceae	Abies concolor	white fir	Perennial	Native		seedling				T																	T							
Tree	Pinaceae	Pinus contorta	lodgepole pine	Perennial	Native		Veg.																												
Tree	Pinaceae	Pinus jefferyi	Jeffrey pine	Perennial	Native		seedling						T																						

2007 Species List for Northstar long term plots. T = trace amounts of cover

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Noxious/ Invasive	In seed mix?	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Native
Tree	Pinaceae	Abies concolor	white fir	Perennial	Native																											T			
Forb	Asteraceae	Achillea millefolium	yarrow	Perennial	Native						T	T	T	T	T	5								T	5				T	T	T			T	
Graminoid	Poaceae	Achnatherum occidentale	Western needlegrass	Perennial	Native		X		5-10	5-10	20-25	15-20	25	5-10	10	30		5	5-10	25	5	5	5-10	20	5	10	10	10	25	5	5	5-10	20	5-10	
Graminoid	Poaceae	Agropyron intermedium /Elytrigia intermedia ssp. Intermedia	intermediate wheatgrass	Perennial	Alien			25	15	10-15	T	T	T	<5	20	5	15	15	10	T	<5		T	T	T	10	10-15	5	T	<5			T	5	
Graminoid	Poaceae	Bromus carinatus	mountain brome	Perennial	Native		X	5 - 10	T	10	T	T	T				10	5	10	20	<5	T				20	10	15-20	15	10	T	5	5		
Graminoid	Poaceae	Bromus inermis	smooth brome	Perennial	Alien																												5	5	
Shrub	Rhamnaceae	Ceanothus velutinus	tobacco brush	Perennial	Native														<5								T								
Shrub	Fagaceae	Chrysolepis sempervirens	Chinquapin	Perennial	native																														30
Forb	Polemoniaceae	Collomia linearis	linear leaf collomia	Annual	Native						T																								
Forb	Boraginaceae	Cryptantha ambigua	Wilke's cryptantha	Annual	Native																				T										
Graminoid	Poaceae	Dactylis glomerata	orchard grass	Perennial	Alien	Invasive									5	T					<5	T	<5	T	T	T					T	<5	5	T	
Graminoid	Poaceae	Elymus elymoides	squirrel's tail grass	Perennial	Native		X	10	30	10-15	35	25-30	10	35-40		10	20	20	T	T	T	55	40	40	35	10	10-15	25		30	50	5	30	15	
Graminoid	Poaceae	Elymus glaucus	blue wildrye	Perennial	Native		X																												
Forb	Polygonaceae	Eriogonum nudum	nude buckwheat	Perennial	Native																											T			
Forb	Polygonaceae	Eriogonum umbellatum	sulfur flower	Perennial	Native			<5		T																									
Forb	Onagraceae	Gayophytum diffusum	prairie smoke	Perennial	Native			T	T														T		T				T	T					
Forb	Brassicaceae	Lepidium campestre	English pepperweed	Annual	Alien													T					T					T		T					
Forb	Linaceae	Linum lewisii	flax	Perennial	Native																				T	T									
Forb	Fabaceae	Lupinus argenteus	silver lupine	Perennial	Native							T									T														
Forb	Fabaceae	Lupinus latifolius	broadleaf lupine	Perennial	Native										T																				
Forb	Fabaceae	Lupinus lepidus (culbertsonii)	Culberton's lupine	Perennial	Native						T									T	T														
Forb	Scrophulariaceae	Penstemon laetus	gay penstemon	Perennial	Native						T													T		T				T		T			
Forb	Hydrophyllaceae	Phacelia hastata	silverleaf phacelia	Perennial	Native																	T													
Graminoid	Poaceae	Poa secunda	Secund's bluegrass	Perennial	Native																					T									
Forb	Asteraceae	Taraxacum officinale	dandelion	Annual	Alien	Of concern						T				T									T					T		T			
Forb	Asteraceae	Tragopogon dubius	false salsify	Annual	Alien					T																								T	
Forb	Fabaceae	Trifolium repens	white clover	Perennial	Alien																									T					
Forb	Scrophulariaceae	Verbascum thapsis	mullen	Annual	Native	Invasive																												T	
		TOTAL						45.5	52.5	42	60	44	37	47	31	51	55.5	45.5	40.5	46	15	60.5	50	62	47	52	34	57	42	50	56	21	65	35	30

T= trace amounts of species
Of concern = evaluated, but not listed by the CIPC (California Invasive Plant Council)